United Nations

Framework Convention on Climate Change

FCCC/TP/2017/2

Distr.: General
13 September 2017

English only

Urban environment related mitigation benefits and co-benefits of policies, practices and actions for enhancing mitigation ambition and options for supporting their implementation

Technical paper by the secretariat

Summary

This updated technical paper compiles information on mitigation benefits and co-benefits of policies, practices and actions for enhancing mitigation ambition in urban environments. It also includes examples of options for supporting the implementation of these policies, practices and actions. The paper is based on presentations and discussions that took place at the technical expert meeting on mitigation, including the collaboration forum, held during the forty-sixth session of the subsidiary bodies, and on a review of the latest literature. It is an update of the technical paper contained in documents FCCC/TP/2014/13 and Add.2, and FCCC/TP/2015/4 and Add.1 and 2. For the updated technical paper on mitigation benefits and co-benefits of policies, practices and actions for enhancing mitigation ambition in land use, see document FCCC/TP/2017/9.

GE.17-15992(E)

Please recycle

Contents

		Paragraphs	*Page*
I.	Background	1–5	3
	A. Mandate	1–2	3
	B. Objective	3–4	3
	C. Structure	5	3
II.	Mitigation potential, progress, benefits, costs and barriers	6–32	4
	A. Potential	13–17	6
	B. Progress	18–20	8
	C. Benefits	21	9
	D. Costs	22–26	9
	E. Barriers	27–32	11
III.	Policy and technology solutions to unlock mitigation potential	33–47	12
	A. Buildings	34–37	13
	B. Transportation	38–39	14
	C. Energy	40–41	15
	D. Waste	42–43	16
	E. Urban form	44–47	17
IV.	Accelerating the implementation of low-emission policies and technology solutions in urban environments	48–66	18
	A. City-level collaboration	49–53	18
	B. Cross-city partnerships	54–61	20
	C. Financial and technical support	62–66	22
V.	Possible next steps to accelerate implementation in the pre-2020 period	67–79	25
	A. Overview of the next steps for accelerating actions that address cross-cutting issues in urban environments	68–71	25
	B. Options for advancing the technical examination process	72–76	26
	C. Options for work at the political level to enhance mitigation ambition	77	27
	D. Possible role of the Marrakech Partnership for Global Climate Action	78–79	27
	References		29

I. Background

A. Mandate

1. This technical paper focuses on mitigation benefits and co-benefits of policies, practices and actions in urban environments for enhancing their mitigation ambition and options for supporting their implementation, and has been prepared in response to a request of the Conference of the Parties (COP) at its twenty-first session.[1] The paper is an update of previous versions[2] and does not supersede them but builds on the findings and information contained therein.

2. The paper is based on information provided at the technical expert meeting (TEM) on mitigation focusing on cross-cutting issues in urban environments, which took place during the forty-sixth sessions of the subsidiary bodies, from 8 to 12 May 2017 in Bonn, Germany.[3] It draws on presentations and discussions that took place during that TEM, including the collaboration forum, and sources of relevant information in the literature.

B. Objective

3. The objective of this technical paper is to present information that has been compiled on mitigation policies, practices and actions that may unlock the mitigation potential in urban environments and facilitate the transition of discussions under the technical examination process on mitigation from policy and action identification to transformational policy and action implementation. With this objective in mind, the paper presents policy options and good practices that can enhance the mitigation ambition of pre-2020 action and support the achievement of the Sustainable Development Goals (SDGs). The experience and lessons learned from implementing policies, practices and actions presented are intended to support Parties and non-Party stakeholders, in particular local governments and municipal authorities, in facilitating the implementation of policies, practices and actions in urban environments identified during this process in accordance with national sustainable development priorities. To facilitate the achievement of this objective, the paper highlights inspirational examples of best practice policies and actions that present valuable lessons and may be replicated and scaled up in the context of unique national circumstances. It also presents examples of support initiatives, enabling practices and successful cooperation for supporting countries, cities and other jurisdictions to address climate challenges, replicate solutions and overcome barriers in order to bring crucial climate goals and the SDGs to fruition and achieve transformational policy implementation.

4. The information presented in the paper does not imply consensus among Parties on any of the issues or options covered at the TEMs. Rather, it provides an overview of the discussions that took place at the TEMs and supplements it with information from the literature.

C. Structure

5. Chapter I contains background information on this technical paper; specifically, its mandate, objective and structure. Chapter II presents information on the mitigation potential, progress, benefits, costs and barriers to actions in urban environments. Chapter III compiles information on policies and technology solutions to unlock the mitigation

[1] Decision 1/CP.21, paragraph 111(c).

[2] Contained in document FCCC/TP/2014/13 and Add.2 and document FCCC/TP/2015/4 and Add.1 and 2.

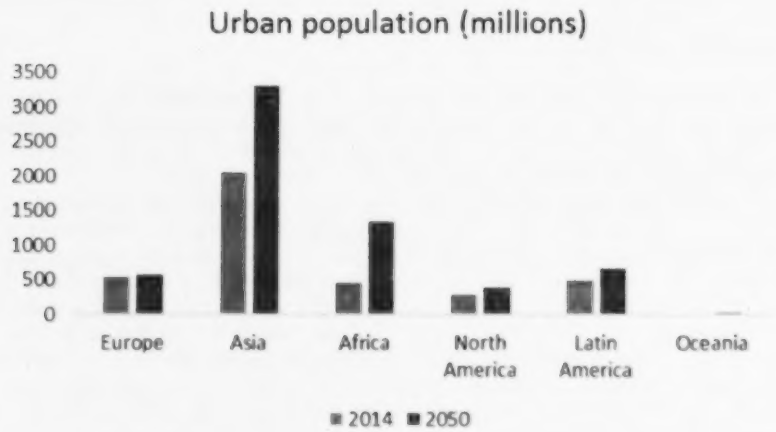
[3] Detailed information on the TEMs held during the forty-sixth sessions of the subsidiary bodies, including the presentations and recordings and the report summarizing the discussions at the meetings, is available at http://unfccc.int/focus/mitigation/technical_expert_meetings/items/8179.php.

potential in urban environments. Chapter IV presents options to accelerate the implementation of these policies and technology solutions through city-level collaboration, cross-city partnerships, and financial and technical support. Chapter V concludes the paper with a recommendation of possible next steps for increasing mitigation ambition in the pre-2020 period.

II. Mitigation potential, progress, benefits, costs and barriers

6. The world is urbanizing at a rapid pace. In 1950, only 30 per cent of the world's population lived in cities. By 2014, the global urban population had increased to 54 per cent, and it is projected to reach 66 per cent by 2050. This means an additional 2.5 billion people will be living in cities by 2050. The pace of urbanization is not even among regions in the world: 90 per cent of the expected urban growth is likely to occur in Africa and Asia, as shown in figure 1.

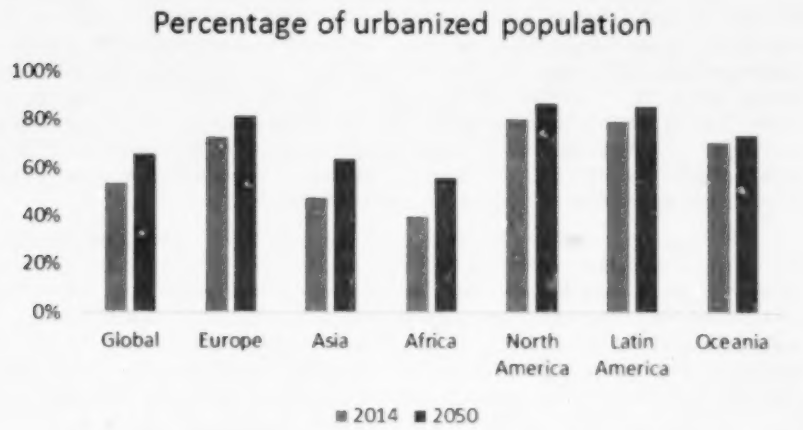
Figure 1
Projections of global urban population growth, by region, to 2050



Source: United Nations Department of Economic and Social Affairs, Population Division. 2015. *World Urbanization Prospects. The 2014 Revision.* Available at https://esa.un.org/unpd/wup/publications/files/wup2014-report.pdf.

7. Figure 2 presents regional urbanization trends to 2050 and shows that it is expected that urbanization will continue in all regions in the world, although from different starting points in terms of the current shares of urban population, and at different paces. As figure 2 shows, North America has the largest share of urban population and it is expected to further increase, from about 82 per cent in 2014 to 87 per cent by 2050. The second most highly urbanized region is Latin America: the share of its urban population is expected to grow from about 80 per cent in 2014 to 86 per cent by 2050. These regions are followed by Europe and Oceania, in which the shares of urban populations are expected to grow from about 73 and 71 per cent in 2014 to 82 and 74 per cent by 2050, respectively.

Figure 2
Projections of share of global urban population, by region, to 2050



Source: United Nations Department of Economic and Social Affairs, Population Division. 2015. *World Urbanization Prospects. The 2014 Revision*. Available at https://esa.un.org/unpd/wup/publications/files/wup2014-report.pdf.

8. Africa and Asia are the only regions to have had the majority of their population living in rural areas in 2014, with urban populations of about 40 and 48 per cent, respectively. These values are projected to increase to 56 and 64 per cent, respectively, by 2050. Urbanization in these two regions will lead to the largest increase in urban dwellers in absolute numbers, though the rates of urbanization in these regions will remain lower than in others (UN DESA, 2015).

9. In addition to differences in urbanization trends among different regions, there are also differences observed within these regions in the growth rates of cities of varying population size. In global terms, megacities (population of over 10 million people) have tripled in number since 1990; in 2014, there were 28 megacities, mostly in developing countries, accounting for 12 per cent of the total global urban population. It is expected that there will be 41 megacities by 2030. However, the majority of people still currently live in smaller agglomerations: in 2014, 43 per cent of the world's urban population lived in cities of less than 300,000 people. The overall percentage of people living in small cities (population less than 1 million) is expected to shrink relative to the percentage living in medium (population 1 to 5 million) and large (population more than 5 million) cities. Small and medium-sized cities are still seeing the fastest rates of urbanization: the percentage of the urban populations living in medium-sized cities doubled from 2000 to 2014 and is expected to increase by 36 per cent by 2030 (UN DESA, 2015).

10. The differences in regional urbanization trends highlight the importance of adapting mitigation strategies and actions to the underlying unique urban context in order to tackle specific challenges and provide tailored solutions and thereby maximize the delivery of mitigation and sustainable development. For example, mitigation in cities that have had a relatively stable population size will need to address the lock-in effect of long-established urban forms[4] and infrastructure through retrofits and upgrading of older infrastructure as it reaches the end of its life cycle. Cities that are rapidly expanding have a significant opportunity to introduce low-emission infrastructure and set themselves on a path of sustainable low-carbon development, but often face considerable pressure on their financial, technical and governance capacity. City size also influences economies of scale with regard to infrastructure use and energy consumption, and the appropriateness of

[4] The physical patterns, layouts and structures that make up an urban centre are collectively called the urban form.

different types of infrastructure for different-sized cities therefore needs to be taken into account (IPCC, 2014b).

11. With the majority of the world's population already living in cities and urbanization projected to increase rapidly over the next 30 years, urban areas are at the forefront of combating climate change. When the Paris Agreement was adopted in 2015, Parties recognized cities as important stakeholders, capable of mobilizing strong and ambitious climate action.[5] The important role of cities in achieving sustainable development is reflected in the SDGs, in particular in SDG 11 ("Make cities inclusive, safe, resilient and sustainable"). Most of SDG 11's 10 targets are directly linked to greenhouse gas (GHG) emission reductions through, for example, sustainable transportation systems, green buildings and the reduction of the environmental impact of cities.[6]

12. Building on the Paris Agreement and the SDGs, the third United Nations Conference on Housing and Sustainable Urban Development in 2016 adopted the New Urban Agenda[7] as a global overarching framework for the development of cities over the next 20 years. The New Urban Agenda aims to promote international, national, subnational and local climate action and to support the efforts of the inhabitants of cities and human settlements and all local stakeholders as important implementers of such action. Furthermore, the New Urban Agenda includes a commitment to reduce GHG emissions from all relevant sectors in line with the goal of the Paris Agreement to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.[8]

A. Potential

13. The Intergovernmental Panel on Climate Change (IPCC) estimates that urban areas account for 67–76 per cent of global energy use and 71–76 per cent of global energy-related carbon dioxide (CO_2) emissions, direct and indirect.[9] The IPCC lists income, population dynamics, urban form, locational factors, economic structure and market failures as the major influences on urban GHG emissions (IPCC, 2014b). A recent meta-analysis of 274 cities worldwide, comprising 21 per cent of the global urban population, found that types of economic activity, transportation, geographic factors and urban form explain 37 per cent of urban direct energy use and 88 per cent of urban transport energy use (Creutzig et al., 2014). Cities with per capita annual incomes of less than USD 10,000 had three times less energy use than those with higher incomes, and the factors most influencing energy use were population density and heating degree days. For higher-income cities, the key factors were petrol prices and population density (Creutzig et al., 2014).

14. Current estimates of urban GHG emissions broken down by sector depend on the data available and the calculations used. Most studies focus on buildings, transportation and waste as the core sectors, those with the most impact on emissions in cities.[10] The International Energy Agency estimates that urban buildings account for approximately two thirds of total energy consumption in the building sector, with 40 per cent of energy use in buildings being for space heating and cooling. Meanwhile, urban transport accounts for 40 per cent of total energy use in the transportation sector, although a significant amount of non-urban transport is also dedicated to meeting the needs and demands of urban residents (IEA, 2016a). A recent study estimates that globally, urban infrastructure (buildings and transportation) accounts for 9.6 Gt CO_2 eq annually (about 20 per cent of global

[5] See the preamble to decision 1/CP.21.

[6] See http://www.un.org/sustainabledevelopment/cities for the targets and more information on SDG 11.

[7] http://habitat3.org/the-new-urban-agenda.

[8] The New Urban Agenda, paragraph 79.

[9] There is still considerable uncertainty in measuring GHG emissions in urban areas owing to differences in accounting systems and their scope, jurisdictional boundaries and the overall lack of data, all of which combined poses a challenge for adequately evaluating the drivers of urban GHG emissions and the impact of policy interventions on mitigation in urban areas (IPCC, 2014b).

[10] FCCC/TP/2014/3/Add.2.

anthropogenic GHG emissions), out of which 6.8 Gt CO_2 eq (70 per cent) are from buildings and 2.8 Gt CO_2 eq (30 per cent) are from transportation (Creutzig et al., 2016). Global emissions from waste and wastewater were estimated at 1.45 Gt CO_2 eq (about 3 per cent of global anthropogenic GHG emissions) in 2010 (IPCC, 2014b). However, there are currently no global estimates for the urban share of global emissions from waste.

15. The rapid growth of urban populations, particularly in Asia and Africa, means that massive expansion of urban infrastructure will be required (IPCC, 2014b). The expansion of energy infrastructure will also be required, both to upgrade current inadequate services and to support the expanding urban population. An estimated 30–40 per cent of urban dwellers in developing countries do not have access to modern forms of energy such as electricity or clean cooking fuel (UN-Habitat, 2013). While cities in the Americas, Europe and Oceania are not experiencing the same rapid rates of urbanization, they too have significant infrastructure gaps because their infrastructure is ageing and needs to be replaced. Historical underinvestment and public spending cuts as a response to the 2008 financial crisis have resulted in an infrastructure investment shortfall of USD 350 billion per year, with additional investment required to meet the SDGs (McKinsey Global Institute, 2016). Directing infrastructure investment towards low-emission options offers significant mitigation potential and should be ensured (IPCC, 2014b).

16. Three recent studies reflect the range of potential mitigation scenarios for cities. The New Urban Economy (GCEC, 2015) estimates that investing in low-emission measures such as energy efficiency and retrofits in buildings, modal shifts and reduced transport demand in transportation, and recycling and landfill gas capture in waste could result in a total average abatement of 8 Gt CO_2 eq annually from 2015 to 2050 (see table 1 for a breakdown of emission abatement and related costs by policy measure). Another recent study estimates that using state-of-the-art building design principles for new buildings and retrofitting existing building stock and introducing road pricing and providing public transport could reduce global urban emissions by 27–57 per cent by 2050 over 'business as usual' (Creutzig et al., 2016). While density, high connectivity and adoption of emerging low-emission technologies in transportation and construction can reduce energy demand and associated emissions, adoption of clean energy technologies will still be necessary to remain within an emission budget compatible with a lower than 2 °C global temperature rise because of the need to build new infrastructure in rapidly urbanizing regions (Creutzig et al., 2016). With the rapid expansion of cities, particularly in developing countries, adopting a mixed-use and public transport oriented approach to development, with energy-efficient buildings integrated with district heating and cooling networks that rely on low-emission fuels or waste heat from industrial plants, will not only avoid a high-emission lock-in effect but also increase access to modern energy services, improve mobility and potentially improve standards of living. Under this scenario, the urban primary energy demand of countries that are not members of the Organisation for Economic Co-operation and Development (OECD) would grow by about 40 per cent by 2050, but the carbon intensity of these countries' cities would fall while their urban economies would more than quadruple (IEA, 2016a).

17. The drivers of urban GHG emissions are diverse and include economic and income factors, sociodemographic factors, technology, infrastructure and urban form – and also the interaction of these factors with each other (IPCC, 2014b). This technical paper focuses on those areas where municipal governments are more likely to have the jurisdiction and power to develop low-emission infrastructure and facilities, provide low-emission urban services and make relevant investments that may have significant mitigation impact; namely, in urban infrastructure such as buildings, transportation, waste and wastewater, and urban form (OECD, 2014). The paper also addresses the energy sector, as some municipalities are taking steps to enable uptake of renewable energy. It necessarily excludes influencing factors such as income, urban economy or industrial base, and demographics, as well as areas that may be the responsibility of municipal authorities and important to sustainable urban development but that have smaller mitigation impacts, such as green space (IPCC, 2014b).

B. Progress

18. Many cities are showcasing the progress they have achieved in mitigation actions in urban environments and are laying the foundation for accelerating them. In so doing, an increasing number of cities are preparing climate action plans and reports and using global platforms to communicate their climate actions. As at November 2016, 2,578 cities in 118 countries, representing 10.2 per cent of the global population, had registered their commitments to climate action on the UNFCCC Non-State Action Zone for Climate Action (NAZCA).[11] It is estimated that these commitments, when implemented, will result in a reduction in emissions of 0.92 Gt CO_2 eq by 2020 and 2.8 Gt CO_2 eq by 2050 (Data-Driven Yale, 2016).[12]

19. Some networks of cities are beginning to communicate their progress towards achieving GHG emission reductions, such as the Covenant of Mayors for Climate and Energy (Covenant of Mayors),[13] whose members have achieved an accumulated reduction in emissions of 23 per cent against their cumulative self-selected baselines[14] within the 2012–2014 period (Covenant of Mayors, 2016).

20. Insufficiency in the quantity of data and variability in the quality of data on GHG emissions create uncertainty in the evaluation of the impact and cost-effectiveness of policy choices. This lack of data has been identified as one of the biggest challenges to developing evidence-based strategies for low-emission urban development today (UN-Habitat, 2017). To address this challenge, some networks of cities have begun to use standardized data collection and emissions accounting methodologies, allowing for a clearer picture of current urban emissions, the development of evidence-based policies and actions and the progress of implementation to be measured. For example, the Covenant of Mayors uses an open source methodology, developed by the European Commission Joint Research Centre, to publish an annual report that tracks planned and achieved GHG emission reductions among the signatories to the Covenant of Mayors. Likewise, the two largest networks of cities, ICLEI-Local Governments for Sustainability (ICLEI)[15] and C40 Cities Climate Leadership Group (C40),[16] have jointly developed the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories[17] to enable cities and communities to measure and report urban GHG emissions in a consistent manner and to use the data collected to develop evidence-based climate action plans and low-emission urban development strategies. ICLEI and C40 also provide reports and case studies on the implementation of mitigation and adaptation actions with emission reductions accounted for and reported.[18] With improved data and knowledge sharing, more cities will be able to choose the most cost-effective mitigation strategies that are evidence-based and locally appropriate. This, in turn, will lay a solid foundation for accelerating the development and implementation of mitigation actions facilitated through planning and collaboration.

---

[11] NAZCA is a global platform that captures the commitments to climate action by companies, cities, subnational regions, investors and civil society organizations. For more information, see http://climateaction.unfccc.int.

[12] Information relating to the commitments recorded on NAZCA has been provided by the largest international platforms for reporting of cities' climate actions; namely, Carbon Disclosure Project, Carbon Climate Registry, the Climate Group, the Investor Group on Climate Change, the United Nations Global Compact, the Covenant of Mayors, the Climate Bonds Initiative and the Climate Initiatives Platform of the United Nations Environment Programme.

[13] http://www.covenantofmayors.eu/index_en.html.

[14] Cities in the Covenant of Mayors select their own baseline year from 1990 to 2009. The emission reductions are calculated based on the difference between each city's self-reported baseline inventory and the inventory at the time of its self-reported monitoring report. Not all member cities have issued monitoring reports and therefore they are not included in the evaluation.

[15] http://www.iclei.org.

[16] http://www.c40.org.

[17] http://www.iclei.org/activities/agendas/low-carbon-city/gpc.html.

[18] See for example Sustainia and C40 (2016).

C. Benefits

21. While curbing urban GHG emissions is imperative for keeping global warming well below 2 °C, mitigation actions also provide a variety of immediate sustainable development co-benefits at the local and regional levels. These co-benefits can be crucially important decision-making criteria for policymakers (for more information, see IPCC, 2007). For example, energy-efficiency and fuel-switching programmes can improve air quality and generate economic benefits in addition to GHG emission reductions. Public transport such as bus rapid transit (BRT) systems, in addition to its demonstrated GHG emission reduction, reduces road traffic fatalities, road congestion, travel times and the percentage of respiratory deceases caused by poor urban air quality. Solid waste management can provide economic opportunities to low-income groups and improve public health. Other examples of sustainable development co-benefits of urban GHG mitigation strategies include energy supply security through increased diversity in energy sources, improved health through reduced pollution, increased employment opportunities and saved energy costs. Co-benefits provide additional motivation for undertaking more ambitious urban mitigation actions, and strategies to "bundle issues" have proven successful in generating local support and action (IPCC, 2014b).

D. Costs

22. Cities play a crucial role in combating climate change as they are often responsible for spending on infrastructure that has direct impacts on the climate system. On average, 75 per cent of total government spending on environmental protection is made by subnational governments (LEDS, 2014). Decisions made by municipal governments relating to land use, transportation, building types and density of construction, and waste management all impact energy use and consumption of other resources and guide private sector investment.

23. Approximately USD 90 trillion investment in infrastructure is expected to take place over the next 15 years to replace ageing and build new infrastructure (GCEC, 2016), with an estimated 70 per cent of that investment to occur in urban areas (CCFLA, 2015). The Global Commission on the Economy and Climate suggests that a shift to low-emission infrastructure could be realized for only 5 per cent additional costs, which would bring about long-term savings due to lower energy and infrastructure costs. At the same time, compact urban development could reduce global urban infrastructure requirements by more than USD 3 trillion from 2015 to 2030 (GCEC, 2016).

24. A finer-grained examination of investment in low-emission urban infrastructure suggests that USD 977 billion investment per year from 2015 to 2050 would reduce annual energy expenditure by USD 1.58 trillion by 2030 and by USD 5.85 trillion by 2050, reducing emissions by 8 Gt CO_2 eq by 2050, as shown in table 1.

Table 1
Potential urban emission abatement and cost by sector in 2030

Sector	*Measure*	*Annual emission abatement 2050 (Gt CO_2 eq)*	*Share of total emission abatement (%)*	*Total incremental investment (2015–2050) (USD trillion)*	*Net present value (USD trillion)*	*Average payback (years)*
Buildings – residential	New building heating efficiency	1.2	15.0	5.3	2.1	8.4
	Heating retrofits	0.5	7.0	6.4	–0.3	20
	Appliances and lighting	0.9	11	0.1	3.7	0.2
	Fuel switch/solar photovoltaic	0.2	3.0	0.7	0.2	11
Buildings – commercial	New building heating efficiency	0.5	7.0	6.6	–2.1	21
	Heating retrofits	0.2	3.0	4.0	–0.7	23.0
	Appliances and lighting	0.7	8.0	0.4	3.0	1.0
	Fuel switch/solar photovoltaic	0.2	3.0	0.2	0	13.0
Subtotal buildings		**4.5**	**57.0**	**23.7**	**6.0**	**17.4**
Transport – passenger	Urban planning: reduced travel demand	0.5	6.0	–	2.9	–
	Mode shift and transit efficiency	1.0	12.0	6.9	1.4	1.6
	Car efficiency and electrification	0.9	11.0	2.5	3.8	4.9
Transport – freight	Logistics improvements	0.2	2.0	–	0.4	–
	Vehicle efficiency and electrification	0.3	4.0	1.0	2.2	4.5
Subtotal transport		**2.8**	**35.0**	**10.4**	**106**	**11.9**
Waste	Recycling	0.3	4.0	–	–	–
	Landfill gas	0.3	4.0	0.03	0	2.0
Subtotal waste		**0.6**	**8.0**	**0.03**	**0**	**2.0**
Total		**8.0**	**100.0**	**34.2**	**16.6**	**15.7**

Source: Adapted from table 2 in New Climate Economy. 2015. *Accelerating Low-Carbon Development in the World's Cities*. Contributing paper for *Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate*. Available at http://newclimateeconomy.report/2015/wp-content/uploads/sites/3/2015/09/NCE2015_workingpaper_cities_final_web.pdf.

25. The values in table 1 do not include avoided investments, reductions in current costs and savings due to co-benefits. The International Monetary Fund estimates subsidies, including the costs of addressing health impacts and other externalities as well as direct price subsidies for fossil fuel energy generation, at USD 5.3 trillion worldwide in 2015 and suggests that these subsidies would be substantially reduced with a shift to low-emission development (IMF, 2015).

26. The costs of implementing mitigation strategies in urban areas are not prohibitive and are likely to save money in the long term. Cost challenges result largely from

fragmented markets, inadequate access to financing, split incentives and the difficulty of aligning long-term investment with short political cycles (see table 2).

E. Barriers

27. Cities are complex systems whose inhabitants and functions are dependent on water, food and energy from far beyond their administrative jurisdictions and, for this reason, they experience the flow of people, goods, information, and financial and natural resources within and beyond their boundaries. They also face a complex interplay of barriers that are unique to each city and include the lack of adequate data to support decision-making and challenges in municipal governance and related institutional, legal, financial and cultural challenges, all of which impact the development and implementation of urban mitigation strategies.

28. Data on a wide range of urban issues are insufficient and in spite of the large number of cities that ostensibly have climate or sustainability plans encompassing climate change issues, accounting and reporting procedures are still weak (IPCC, 2014b). Many cities lack even basic data on population and infrastructure use, with, for example, poor migrants and inhabitants living in unplanned settlements not being included in population or spatial statistics. Furthermore, data collection is often either done by higher levels of government and not oriented towards urban decision makers or restricted to areas under the jurisdiction of local authorities. This limits the understanding of economic, social and environmental flows between the city and its outskirts. More and more data are available on, for example, building and transportation energy use, but they may be gathered by private sector companies or consultancies and are thus proprietary and not available for use by local authorities (UN-Habitat and UNESCAP, 2015).

29. Municipal administrations are limited geographically and in scope, constrained by higher levels of government and institutional complexity. Some cities suffer from fragmentation, poor communication and a lack of coordination among departments, agencies and higher levels of government.[19] Perverse incentives, such as competition for budgets and credit, may discourage learning, sharing and transparency. Some municipal governments do not have adequate access to financing for low-emission infrastructure investment. Cities may not have a mandate to address climate-related issues. Some municipal staff have no capacity to evaluate or implement mitigation strategies, and changes in administration can result in the loss of institutional memory, the loss of staff capacity and the disruption of networks and multi-sectoral partnership coordination. Differences in political party affiliation may impact coordination between municipalities and higher levels of government. The lack of experience, capacity and incentives may limit municipal engagement with the public (LEDS, 2014).

30. Addressing climate change requires coordination not only among departments, agencies and levels of government, but also of the government with a wide range of urban actors outside it. Municipalities can play a critical role in coordinating multiple actors and educating them in driving forward climate-friendly solutions in urban spaces.[20]

31. The IPCC has identified multiple sectoral barriers to the uptake of low-emission technologies in specific sectors, including sector-specific institutional, legal, financial and cultural barriers. Examples of barriers relevant for key urban sectors are presented in table 2.

[19] For example, responsibilities for transportation and land use usually reside within different departments of local government and municipal authorities.

[20] FCCC/TP/2015/4.

Table 2
Barriers to the uptake of low-emission technologies in cities

Sector	*Barriers*
Buildings	Split incentives for investment in energy efficiency measures (e.g. among builders, owners and tenants)
	Fragmented markets and inadequate access to information and financing
	Lifestyle choices (e.g. use of air conditioning and heating)
	Lack of skilled technical personnel for maintenance and management of low-emission buildings
Transportation	Established infrastructure and land-use patterns may limit modal shifts (e.g. lack of alternative modes of transportation, insufficient population density favours cars)
	More efficient vehicles may limit modal shifts (i.e. they lower cost and improve local air pollution impacts, but have less mitigation impact than shifting to public transport)
	Uncertainties with regard to environmental impacts of low-emission transport technologies (e.g. environmental impact of fuel cells and biofuels)
	Psychological and cultural barriers such as sunk costs or behaviour momentum, fear of change, negative perceptions of public transport, safety concerns, opposition to rising parking or congestion costs or other restrictions
Energy	Technical: siting, storage and systems balancing
	Financial: large upfront capital costs, new financial instruments are required to mobilize private funding (e.g. feed-in tariffs), uncertainty due to instability in policies (e.g. cancellation of feed-in tariffs)
	Cultural, institutional and legal: perceived entitlement to cheap and abundant energy, negative public perception of certain types of renewable energy (e.g. nuclear energy safety issues, local environmental impact of hydropower)
	Human capital: lack of training for technical skills and policy support
	Energy stock inertia: long life cycles and slow turnover of energy facilities
Waste and wastewater	Cost (e.g. for recycling, landfill, waste-to-energy, wastewater treatment facilities)
	Lack of public acceptance and education (e.g. for waste reduction, recycling)

Source: Examples compiled from: Intergovernmental Panel on Climate Change. 2014. Human settlements, infrastructure and spatial planning. *In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter12.pdf.

Note: This list is not exhaustive and the examples are provided for information only.

32. Chapter II.A–D above have shown mitigation potential, progress, benefits and costs of low-emission urban development. While many barriers identified in this chapter are challenging to overcome, promising policy and technology solutions for overcoming some of them are being successfully pioneered, as discussed in the following chapter.

III. Policy and technology solutions to unlock mitigation potential

33. Innovative policies and technology solutions can not only unlock the untapped mitigation potential, but also deliver multiple sustainable development co-benefits, as described in chapter II.C above. In urban environments, the greatest mitigation potential lies in the building and transportation sectors and is underpinned by compact urban forms and renewable energy. The urban waste management sector also offers mitigation potential, which increases significantly if understood to include the consumption patterns of urban residents.

A. Buildings

34. Buildings and construction account for about 40 per cent of global energy-related GHG emissions. The improvement of building energy performance carries a large potential for cost-effective emission reductions and cost savings in the long term (UNEP, 2016). While building energy performance has been improving by about 1.5 per cent per year since 1990, these energy savings have been offset by the demand for larger spaces, smaller households and an increase in energy services. Space heating in buildings accounts for one third of their energy use. Water heating consumes almost as much energy as space heating, and cooking, appliances and lighting follow (UNEP, 2016). Cooling consumes less energy, but its consumption is expected to grow as temperatures rise globally. In addition to rising energy demand for cooling, which will lead to growth in associated GHG emissions, refrigerants used in refrigeration and cooling equipment and blowing agents used in foam for insulation to maintain appropriate temperature ranges in buildings applications (commonly known as F-gases) are also important contributors to GHG emissions owing to their large global warming potential, and demand for such refrigerants and blowing agents is also likely to grow as a result of increased demand for cooling (for more information see IPCC, 2014a). An example of a policy intervention that tackles both energy-related and refrigerant-related emissions from refrigeration and air conditioning in urban areas is presented in box 1.

Box 1
Low-emission and energy-efficient cooling in urban environments in Indonesia

Refrigeration and air conditioning in Indonesia's urban areas accounts for about 40 per cent of national energy consumption and 15.4 per cent of national greenhouse gas emissions, excluding emissions from land use, land-use change and forestry. In line with the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, the country has decided to promote low-emission and energy-efficient refrigeration and air-conditioning technologies by developing a cross-ministerial programme on phasing out hydrofluorocarbons and incentivizing the purchase of propane-based energy-efficient air conditioners and refrigerators.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

35. Approximately 60 countries have introduced building energy codes and standards to improve the energy efficiency of buildings (UNEP, 2016). Introducing average performance requirements of these codes and standards globally would have led to a reduction of 6 per cent in global residential energy use in 2015 (UNEP, 2016). Most jurisdictions measure energy performance through modelling at the design stage, although some are starting to use outcome-based approaches, as construction and maintenance can impact on energy performance.[21] Setting standards for performance of existing buildings incentivizes retrofits. Voluntary building energy certification or labelling such as Leadership in Energy and Environmental Design[22] or the Building Research Establishment Environmental Assessment Method[23] create market incentives. Similarly, setting standards for appliances and lighting improves energy efficiency (IEA, 2016b).

36. Financial incentives are another important tool for improving the energy efficiency of buildings. Incentives may include tax credits, rebates, loans, grants, green mortgages and bridging loans. Governments, at the national and subnational levels, can support the development of energy service companies by employing their services for public buildings, clarifying their legal and tax status, enabling their coordination with energy companies, and implementing building codes and audit and retrofit programmes.[24]

[21] https://www.wbdg.org/resources/outcome-based-pathways-achieving-energy-performance-goals.
[22] http://www.usgbc.org/help/what-leed.
[23] http://www.breeam.com.
[24] FCCC/TP/2015/4.

37. Local authorities have a role to play in education, training and leadership in the green building sector. They can educate builders, investors and consumers on the benefits of green buildings, enable coordination among stakeholders, and participate in demonstration and pilot projects to improve energy efficiency in buildings through retrofits and implement such improved energy efficiency in new construction.[25] Examples of policy options and measures for energy-efficient buildings are given in box 2.

Box 2
Examples of energy-efficient building policies and measures

- Boulder, United States of America: Smart Suite energy efficiency programme integrates regulations, energy services and financing
- London, United Kingdom: Public and residential building retrofit programmes RE:FIT and RE:NEW
- Melbourne, Australia: Smart Blocks online tools provide building residents with information on retrofit options and payback periods
- Rotterdam, Netherlands: 219,000 square metres of green roofs absorb 82 tonnes of carbon dioxide and retain 15 litres of rain water per square metre
- Salvador, Brazil: Graduated discounted property tax depending on building's sustainability certification
- Seoul, Republic of Korea: Eight-year loans at 1.75 per cent interest that cover all retrofit expenses for residents, tenants, landlords or businesses
- Toronto, Canada: Toronto Green Standard mandatory and reward-driven voluntary standards for all new construction

Source: FCCC/TP/2015/4 and information presented during the technical expert meeting on mitigation, including the collaboration forum, held in May 2017.

Note: This list is not exhaustive and the examples are provided for information only.

B. Transportation

38. Transportation worldwide accounts for 22 per cent of total global energy use (IEA, 2016a). Integrated mobility systems that induce modal shifts have the potential to reduce GHG emissions from the transportation sector by 50 per cent by 2050 compared with a 2011 baseline (Creutzig et al., 2015). Increasing petrol prices, congestion charges and parking fees, combined with the enhanced provision of public transport and infrastructure for non-motorized transport, have been demonstrated to decrease car use (OECD, 2014). Both public transport, including buses and underground railway, BRT and light rail systems (see box 3), and non-motorized transport, such as cycling and walking, are key components of a low-emission urban transport system and are critical for curbing the growth of urban transport-related emissions.

[25] FCCC/TP/2015/4.

Box 3

Bus rapid transit systems for low-emission urban development in China

Over the past 15 years, 35 cities in China have developed a bus rapid transit (BRT) system. The city of Guangzhou, which hosts the BRT system with the second highest passenger capacity in the world, received a UNFCCC Momentum for Change award for Lighthouse Activities in 2012. The city of Yichang has developed a unique bus station design for narrow roads, which reduces the regular station length by 50 per cent and will allow more cities to introduce a BRT system in the future. A BRT system can be built at one tenth to one hundredth of the cost and one fifth of the time of a metro system with comparable passenger capacity. The BRT system of Yichang was inspired by the BRT system in Bogota, Colombia, launched in 2000, and Yichang is now supporting four other cities in China as well as Addis Ababa in Ethiopia, Manila in the Philippines and Vientiane in the Lao People's Democratic Republic to develop BRT systems.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

39. Electric vehicles hold promise for decarbonizing the transportation system, particularly in suburban areas that will not densify sufficiently to support public transportation systems in the immediate future. Plug-in electric vehicles can emit up to 54 per cent less CO_2 emissions per kilometre than a conventional vehicle (EPRI, 2015). However, for electric vehicles to make a significant contribution to reducing emissions in the transport sector, the expansion of the charging infrastructure and an overall shift to renewable energy as their source of electricity is required (IRENA, 2016). Examples of policy options and measures supporting low-emission transportation are given in box 4.

Box 4

Examples of low-emission transportation policies and measures

- Chennai, India: Street Design Project, with 60 per cent of transportation budget invested in non-motorized transport infrastructure
- Copenhagen, Denmark: Bicycle highway
- Hangzhou, China: Largest bike share programme in the world
- Houston, United States of America: Expansion of light rail and New Bus Network
- Medellín, Colombia: Cable car system integrated with underground railway, bus rapid transit and tram systems; locally appropriate transportation, access to informal settlements
- Mexico City, Mexico: ECOBICI integrated transportation system: one card to access bike share, buses and trains
- Milan, Italy: Electric car, bike and scooter sharing scheme
- Stockholm, Sweden: Congestion tax
- London, United Kingdom: Congestion charge

Source: FCCC/TP/2015/4 and information presented during the technical expert meeting on mitigation, including the collaboration forum, held in May 2017.

Note: This list is not exhaustive and the examples are provided for information only.

C. Energy

40. The sources of power supplying a city have a major impact on its GHG emissions. Power generation is usually managed by utilities operated by public or private sector companies and is not controlled by local governments or municipal authorities. While the decarbonization of the power sector at the national level is important, cities can participate in small-scale renewable and low-emission energy production. These activities include the construction of net zero energy buildings that produce on-site energy, for example through

solar photovoltaics and micro wind turbines. Waste-to-energy plants that use municipal waste are becoming more widespread (see box 5).

Box 5
Lowering emissions through a cycle-based waste management system in Norway

The city of Oslo has established a cycle-based waste management system that allows it to reuse 2 per cent, recycle 39 per cent and convert into energy 57 per cent of its municipal waste. Only the remaining 2 per cent goes into landfill. The city has two waste-to-energy plants with a total capacity of 450,000 t per year that generate 175 GWh per year electricity and 1,000 GWh per year district heating. Greenhouse gas emissions are reduced not only by avoiding landfill, but also through the production of electricity, heat and fertilizer from the waste as well as post-incineration carbon dioxide capture.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

41. Although district heating systems most commonly use natural gas, they can also use energy from other, including renewable, sources, such as municipal waste, waste biomass, heat recovery from sewage systems or from buildings such as grocery stores, cold storage facilities or ice rinks that produce relatively large amounts of wasted heat as a result of their cooling needs. Wastewater treatment plants can generate on-site energy after installing micro hydro systems. Local authorities can adopt these technologies in public buildings and publicly owned infrastructure. They can also increase their uptake through requirements in building codes; for example, a requirement for the inclusion of solar hot water systems. Cities can provide stability and incentives for the expansion of the renewable energy market as clients with long-term commitments to purchasing green power (IRENA, 2016). Examples of policy options and measures supporting low-emission urban energy systems are given in box 6.

Box 6
Examples of low-emission urban energy policies and measures

- Buenos Aires, Argentina: Street light retrofit with smart light-emitting diodes
- Cape Town, South Africa: An accredited Solar Water Heater Programme created trust in installation companies and increased residential uptake of solar hot water heaters
- Houston, United States of America: 15 purchase power agreements for a 30 MW solar power plant
- Nelson Mandela Bay Municipality, South Africa: Small-scale embedded energy generation by individuals and companies
- Paris, France: 10-year energy performance contract for public lighting and luminous signage installations
- Singapore: SolarNova programme, a public–private partnership for solar power, with 100 MW capacity installed by 2015
- Vancouver, Canada: Neighbourhood energy utility sewage heat recovery
- Yokohama, Japan: Yokohama Smart City Project installs energy management systems in homes and smart-grid technology citywide

Source: FCCC/TP/2015/4 and information presented during the technical expert meeting on mitigation, including the collaboration forum, held in May 2017.

Note: This list is not exhaustive and the examples are provided for information only.

D. Waste

42. Global emissions from waste and wastewater are estimated at 1.45 Gt CO_2 eq or almost 3 per cent of total GHG emissions as of 2010, largely from methane released from landfills (IPCC, 2014b). Calculations are challenging because the collection of accurate

data for the amount and type of solid waste is not done by many countries and regions, and accounting systems are not standardized. Nevertheless, it has been estimated that, since 2010, 7–10 billion tonnes of household, construction, industrial and commercial waste have been produced annually. Household waste that municipal authorities are responsible for managing constitutes approximately 2 billion out of these 7–10 billion tonnes (UNEP and ISWA, 2015). The New Climate Economy estimates the potential for emission reductions through improved recycling rates and landfill management in the urban waste sector to be 0.6 Gt CO_2 eq. However, the United Nations Environment Programme and the International Solid Waste Association (UNEP and ISWA, 2015) suggest that by using a life cycle approach that includes better waste management, such as sanitary landfills and waste-to-energy technologies, as well as avoids resource extraction and reduces the energy consumed in production processes and the use of recycled materials, the potential emission reductions could reach 10–15 per cent of current global emissions.

43. Although much of the potential emission reductions in the waste sector are to be found in more efficient industrial and agricultural processes and reduced resource extraction, cities are also contributing to reductions through better waste management systems and consumer education on waste reduction, recycling, composting of organic waste and use of waste-to-energy facilities. As urban waste management is usually under the control of local authorities, it offers opportunities for quick action that has many co-benefits, such as improved public health, sanitation and employment, particularly in cities where informal waste picking is common. Examples of policy options and measures supporting low-emission waste management are given in box 7.

Box 7

Examples of low-emission waste management policies and measures

- Bogotá, Colombia: Zero Waste programme increased recycling, formalized informal waste pickers and installed a biogas plant at one of the city's landfills
- Guangzhou, China: Improved waste separation increases recycling and supplies waste-to-energy plants and organic composting plants
- Delhi, India: Composting plant turns organic waste into fuel for cement factories
- Belo Horizonte, Brazil: Waste-to-energy through landfill biogas capture
- Durban, South Africa: Buffelsdraai Landfill Site Reforestation Project led to the planting of 750,000 trees
- Hong Kong, China: Food Wise Campaign to reduce food waste

Source: FCCC/TP/2015/4 and information presented during the technical expert meeting on mitigation, including the collaboration forum, held in May 2017.

Note: This list is not exhaustive and the examples are provided for information only.

E. Urban form

44. A compact urban form makes non-motorized and public transport options viable, increases the potential for energy-efficient buildings and efficient energy distribution, and makes green infrastructure more feasible (IPCC, 2014b). Since the mid-1950s, urban land area has doubled in OECD countries and quintupled in non-OECD countries (OECD, 2014). Although cities occupy only about 3 per cent of the world's land mass, urban forms impact energy and resource consumption far beyond city boundaries. The energy savings of dense city cores and the high energy consumption of sprawl and suburban development are well documented.[26]

45. The IPCC identifies four main characteristics of urban form: density, land-use mix, connectivity and accessibility (IPCC, 2014b). High-density development supports lower-emission travel modes and can make energy-efficient buildings more feasible. Different building configurations have different implications for emissions. Medium-rise buildings

[26] See for example http://www.newurbanism.org/sprawlcosts.html.

(less than seven storeys) are able to accommodate comparable numbers of people but require less materials and embodied energy than high-rise buildings. Mixed-use developments accommodate homes, jobs, services and amenities in close proximity, lessening travel needs. Smaller blocks with finer grained streets promote connectivity, facilitating walking and other non-motorized forms of transport. In summary, dense, mixed-use and well-connected cities are accessible cities, where residents are in close proximity to or have multiple transport options to access housing, jobs and services (IPCC, 2014b).

46. While low-emission technologies are critical to reducing emissions, understanding how the various sectors with the greatest impacts on emissions fit together and influence each other is just as important for realizing maximum mitigation potential. Integrated spatial planning is needed at the regional, city, district, corridor, neighbourhood, community and street level, and needs to consider the balance between jobs and housing and how physical design can support the economic and social development of a city. The city's development, in turn, influences emission levels (IPCC, 2014b). Examples of policy options and measures supporting integrated low-emission city planning are given in box 8.

Box 8

Examples of integrated low-emission city planning policies and measures

- Heidelberg, Germany: Bahnstadt district rehabilitated brownfield site in the city centre; Passivhaus construction serviced by transit and car sharing
- Portland, United States of America: Urban growth boundary
- São Paulo, Brazil: Developers must compensate the city for the value of land and the cost of new infrastructure, incentivizing transit-oriented development
- Shenzhen, China: Prioritization of transit-oriented development in city plans and building codes; provision of innovative financing options for developers around transit hubs
- Bogor, Indonesia: Urban-LEDS Model City, a five-year low-emission development strategy
- Seoul, Republic of Korea: A citizen-led initiative to reduce greenhouse gas emissions by 10 million tonnes by 2020
- Sydney, Australia: Sustainable Sydney 2030

Source: FCCC/TP/2015/4 and information presented during the technical expert meeting on mitigation, including the collaboration forum, held in May 2017.

Note: This list is not exhaustive and the examples are provided for information only.

47. Chapter III has discussed successful policies and technology solutions that support low-emission development in urban environments in the areas of buildings, transportation, energy, waste and urban form. The next chapter will present examples of how the implementation of these low-emission policies and technology solutions can be accelerated through collaboration among stakeholders within cities and partnerships between cities as well as through financial and technical support.

IV. Accelerating the implementation of low-emission policies and technology solutions in urban environments

48. This chapter presents examples of enabling practices for accelerating the implementation of low-emission policies and technology solutions presented at the TEM (see para. 2 above). Examples are provided in three thematic areas: city-level cooperation, cross-city partnerships, and financial and technical support from bilateral and multilateral sources.

A. City-level collaboration

49. This chapter highlights examples of collaborative actions of local governments and municipal authorities with key stakeholders at the city level. The broad participation of

stakeholder groups, including private companies, homeowners, citizens, civil society, research organizations, financial institutions and the media, is a prerequisite to scale up and replicate local mitigation actions at the city level.

50. As discussed in chapter III above, low-emission city planning, infrastructure, buildings, industry, mobility, energy generation and use, energy efficiency and waste are important areas that need attention from local governments and municipal authorities. The development and implementation of innovative approaches in many of these areas hinge on the effective engagement of a city's diverse stakeholder groups. There are various ways to incentivize the participation and active engagement of stakeholders. For example, the private sector requires a clear business case for investment (see box 9).

Box 9
Public–private partnership for low-emission electricity generation in Singapore and Cambodia

Singapore's SolarNova programme is a solar rooftops programme for government facilities that uses an innovative business model where the private sector installs, owns and operates the solar systems and generates revenue through a power purchase agreement with the government. A national solar institute conducted the necessary technical feasibility studies and supported the development of the business case. A first round of installations with a total capacity of 76 MW peak[a] was successfully tendered in 2015 and a second round at a capacity of 40 MW peak[b] is currently under way. This model is already being replicated by Singaporean companies in Cambodia.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

[a] See: Allan L and Tao J. 2016. Singapore country Report. In: S Kimura and P Han (eds.). *Energy Outlook and Energy Saving Potential in East Asia 2016*. ERIA Research Project Report 2015-5. Available at http://www.eria.org/RPR_FY2015_No.5_Chapter_15.pdf.

[b] See http://www.hdb.gov.sg/cs/infoweb/press-releases/solarnova-programme-16102016.

51. Citizens may also be incentivized through educational and behavioural change campaigns that demonstrate the benefits of engagement (see box 10).

Box 10
Engaging citizens in domestic energy saving and low-emission transportation in Singapore

Singapore engages its citizens in utilizing energy management systems at home by providing the necessary hardware and software applications and raising awareness of household cost-saving benefits. The energy management systems allow for the remote operation of air conditioners and lights and send alerts on the possibilities for reducing energy consumption. In addition, some residential apartment blocks have noticeboards that publicly display energy use and waste production to show the achievements of their residents. Singapore also uses information and communication technologies to encourage its citizens to use public transport and car-sharing schemes, including innovative schemes, such as self-driving vehicles and electric vehicle sharing, which is currently being piloted in partnership with a Parisian company.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

52. To ensure broad and long-term city-level collaboration, local governments and municipal authorities need to create an enabling environment where stakeholders can come together to develop innovative solutions for a sustainable urban system. This is also important for institutionalizing good practices so that they continue irrespective of changes in individual office holders (see box 11).

Box 11
Fostering a participatory approach in urban low-emission policymaking and implementation in Germany

In 2013, Bonn, Germany, established a Climate Protection Advisory Committee,[a]

which comprises interested citizens, technical experts and private sector representatives. The committee advises local government on the development and implementation of the city's climate change policies and action plans. Furthermore, the city engages its citizens in low-emission development by offering free advice to private homeowners and tenants on energy-efficient refurbishment and renewable energy through an independent agency. Bonn recognizes education and communication as key for achieving its climate change mitigation targets together with its citizens and undertakes various behavioural change campaigns, such as its Climate Ambassadors initiative for primary school children. By June 2017, about 7,000 children will have received their 'climate licence' upon the completion of an educational programme on environmentally friendly behaviour. The children will then work within their families as ambassadors for instilling behavioural change.[b]

Source: Presentation at the technical expert meeting on mitigation in May 2017.

[a] http://www.bonn.de/umwelt_gesundheit_planen_bauen_wohnen/klimaschutz/engagement/klimaschutzbeirat/index.html?lang=de (in German).

[b] http://www.bonner-klimabotschafter.de (in German).

53. The World Wide Fund for Nature (WWF) provides a global platform for inspiring examples of climate action at the city level through its One Planet City Challenge, which recognizes and rewards cities for their mitigation and adaptation actions. Award-winning cities include Cape Town, South Africa, for demonstrating how low-emission development can be accomplished in line with many competing development priorities, and Seoul, Republic of Korea, for incentivizing the domestic use of solar power and various low-emission transportation initiatives.[27] WWF also compiles good practices on sustainable urban development, including through cross-city partnerships, on its Urban Solutions for a Living Planet platform.[28]

B. Cross-city partnerships

54. This chapter showcases examples of partnerships on climate actions between cities. Through cross-city partnerships, cities can share knowledge, technical expertise and experience to enable the replication of initiatives or the deployment of urban services that result in emission reductions and enhance the liveability of cities. Many national and international city networks provide a great opportunity for cities around the world to foster collaboration.

55. Launched on 1 January 2017, the Global Covenant of Mayors for Climate & Energy brings together the two largest global alliances of cities and local governments for addressing climate change: the Covenant of Mayors and the Compact of Mayors.[29] It is the broadest global alliance committed to local climate leadership, building on the commitment of more than 7,400 cities, representing almost 700 million people worldwide and about 9 per cent of the global population.

56. The Covenant of Mayors unites local and regional authorities voluntarily committed to implementing the European Union's climate and energy objectives on their territory. This unique bottom-up movement, which started in 2008 with the support of the European Commission, now counts over 7,000 signatories, representing more than 230 million inhabitants in 53 countries.[30] It provides its members with: opportunities to contribute to shaping the European Union's climate and energy policies; support for accessing funding sources; innovative ways to network, exchange experiences and build capacity; and access to technical support, tools and resource materials. The Compact of Mayors, representing more than 600 cities, is an agreement by city networks and their members to reduce city-level emissions and to reduce vulnerability and enhance resilience to climate change in a

[27] http://wwf.panda.org/what_we_do/footprint/one_planet_cities/one_planet_city_challenge/.

[28] http://wwf.panda.org/what_we_do/footprint/one_planet_cities/urban_solutions/.

[29] https://www.compactofmayors.org.

[30] http://www.covenantofmayors.eu/about/covenant-in-figures_en.html.

complementary manner with national-level climate protection efforts. This initiative aims for an emission reduction of 3 Gt CO_2 eq by 2030. The Compact of Mayors brings together the world's largest city networks on climate change, including ICLEI, C40 and United Cities and Local Governments (UCLG).[31] More information about these networks is provided below.

57. ICLEI is a global network of more than 1,500 cities, towns and regions committed to sustainable development. ICLEI works through 17 offices in 86 countries, covering over 25 per cent of the global urban population. It provides a wide range of services to cities, including advocacy, tools, research, capacity-building and networks. For example, the Urban Low Emissions Development Strategy project,[32] which is funded by the European Commission and implemented by UN-Habitat and ICLEI, has the objective of enhancing the transition to low-emission urban development in cities in Brazil, India, Indonesia and South Africa. The project has, inter alia, created a global network of cities that serves as an example of South–South–North exchange and peer learning.[33] The ICLEI GreenClimateCities Program[34] provides a methodology, tools and technical support for cities to reduce their GHG emissions. ICLEI has also established the Transformative Actions Program, which aims to catalyse and improve capital flows to cities, towns and regions and strengthen the capacity of local and subnational governments to access climate finance and attract investment.[35]

58. C40 is a global network of cities dedicated to actions that reduce GHG emissions. C40 supports cities by: providing direct assistance for low-emission policies and actions; linking cities with its partner organizations to facilitate technical assistance for policies, programmes and projects; facilitating peer-to-peer exchange; and compiling good practices, challenges and measurements of progress within its network of cities. C40 also convenes 17 thematic networks organized under 7 thematic areas (adaptation and water; energy; finance and economic development; measurements and planning; solid waste management; transportation; and urban planning and development) to support cities in replicating, improving and accelerating climate action.[36] Thematic networks include those that address municipal[37] and private[38] building efficiency, BRT systems,[39] sustainable solid waste systems[40] and sustainable infrastructure finance.[41] Furthermore, the C40 Cities Finance Facility supports C40 cities in developing countries to mobilize finance for city-level climate action, including through the provision of support for preparing project proposals and accessing financing instruments.[42]

59. UCLG is the largest local government network in the world, representing 5 billion people. Members of UCLG are present in 140 countries, including more than 240,000 towns, cities, regions and metropolises and 175 local government associations. UCLG represents local governments at the international level, provides global networking possibilities for local and regional governments and offers a broad range of knowledge products, including through its Municipal eLibrary.[43]

60. The Cities Climate Finance Leadership Alliance[44] is a coalition of more than 40 organizations actively working to catalyse and accelerate investment in low-emission and climate-resilient infrastructure in cities and urban areas.

---

[31] http://www.uclg.org.
[32] http://urbanleds.iclei.org/.
[33] http://urbanleds.iclei.org/index.php?id=1135.
[34] http://www.iclei.org/activities/agendas/low-carbon-city/gcc.html.
[35] http://tap-potential.org.
[36] http://www.c40.org/networks.
[37] http://www.c40.org/networks/municipal-building-efficiency.
[38] http://www.c40.org/networks/private-building-efficiency.
[39] http://www.c40.org/networks/bus_rapid_transit.
[40] http://www.c40.org/networks/sustainable_solid_waste_systems.
[41] http://www.c40.org/networks/sustainable_infrastructure_finance.
[42] http://www.c40.org/programmes/c40-cities-finance-facility.
[43] https://www.uclg.org/en/join-uclg/why-join.
[44] http://www.citiesclimatefinance.org.

61. Chapter IV.A and B above have shown how some of the barriers to low-emission policies and actions can be overcome by fostering collaboration at the city level, for example through a public–private partnership or through working with other cities on addressing data and information gaps through capacity-building programmes offered by city networks.

C. Financial and technical support

62. This chapter presents examples of financial and technical support available through bilateral and multilateral channels, which cities can access either through their national governments or directly.

63. Under the Convention, support mechanisms such as the Financial Mechanism and the Technology Mechanism are geared towards the provision of support at the national level. Subnational governments therefore need to coordinate with the respective national focal points to access financial and technical support from these institutions, including the Global Environment Facility, the Green Climate Fund and the Climate Technology Centre and Network (CTCN). However, there is an increasing trend among these institutions of supporting climate action in urban environments (see box 12).

Box 12

Examples of financial and technical support

Provision of financial support for low-emission urban development by the Global Environment Facility

The Global Environment Facility (GEF) is an operating entity of the Financial Mechanism that enables developing countries to take mitigation and adaptation actions. The GEF has recently launched its Integrated Approach Pilot of Sustainable Cities,[a] through which it supports 27 cities in 11 countries with a total amount of USD 150 million from 2015 to 2020. Investments, which will cover green buildings and waste management, among others, are expected to lead to greenhouse gas emission reductions of 100 million tonnes of carbon dioxide equivalent.

Provision of financial support for low-emission urban development by the Green Climate Fund

The Green Climate Fund (GCF), an operating entity of the Financial Mechanism, is designed to finance low-emission and climate-resilient projects and programmes in developing countries, including in the least developed countries, small island developing States and African States. While the fund does not provide direct support to local governments and municipal authorities, national governments can apply for funding to be used at the city level. An example of a city-level project funded by the GCF is a project on improving energy efficiency through building retrofits in cooperation with the city of Yerevan in Armenia. In this project, the GCF provides financial support to make loans for building retrofits more affordable as well as for technical assistance on removing market and policy barriers to achieve a risk-return profile for energy-efficient building retrofits that can attract more private investments.[b]

Support for technology solutions for low-emission urban development by the Climate Technology Centre and Network

The Climate Technology Centre and Network (CTCN) promotes accelerated, diversified and scaled-up transfer of environmentally sound technologies for climate change mitigation and adaptation in developing countries, in line with their sustainable development priorities. It does so by providing technical assistance, facilitating knowledge-sharing, and supporting collaboration and networking that result in investments in the respective areas. The CTCN has network members from a broad community of climate technology stakeholders, including academic, finance, non-government, private sector, public sector and research entities, specialized in all areas that are key for low-emission urban development, including 182 members in the area of energy efficiency, 175 members in the area of renewable energy, 92 members in the area of waste management, 63 members in the area of transport and 45 members in the area of infrastructure and urban planning. To date, the CTCN has provided technical assistance to three mitigation projects at the city level; namely, on improved sustainability of the district heating system in Banja Luka, Bosnia and Herzegovina; on the development of a green building standard in Thailand; and on municipal waste management

technologies in Ecuador.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

[a] https://www.thegef.org/topics/sustainable-cities.

[b] http://www.greenclimate.fund/-/de-risking-and-scaling-up-investment-in-energy-efficient-building-retrofits-in-armenia.

64. There are other avenues for subnational governments to obtain support for low-emission policymaking and action. Various international financial institutions, such as multilateral development banks, provide loans, grants and technical support at the city level. These include the European Bank for Reconstruction and Development (see box 13) and the Inter-American Development Bank (IDB).

Box 13

The European Bank for Reconstruction and Development's Green Cities Programme

The European Bank for Reconstruction and Development's Green Cities Programme[a] identifies and invests in measures that improve environmental performance in municipalities. It supports the development of strategies and policies; facilitates and stimulates investment in low-emission urban transport, district heating, wastewater and solid waste treatment, and energy efficiency in buildings; and builds the capacity of city administrators and other stakeholders. The Green Cities Programme is being piloted in Yerevan, Armenia, and Chisinau, Republic of Moldova, in the areas of low-emission public transport and energy efficiency in public buildings, respectively.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

[a] http://www.ebrd.com/news/2016/how-to-become-a-green-city.html.

65. Examples of support that the IDB provides for mitigation actions in cities include a loan of USD 25 million to Santo André in Brazil for the development of a BRT system and bicycle lanes to reduce GHG emissions.[45] Another example includes a guide for smart city management developed by the IDB that compiles practical solutions from 50 cities, to support policymakers in developing and implementing effective climate policies and actions.[46]

66. Other examples of new support programmes and tools for cities include the World Bank's Global Platform for Sustainable Cities, the International Renewable Energy Agency's support for the deployment of renewable energy technologies, the German development cooperation agency Gesellschaft für Internationale Zusammenarbeit's support for cities in reducing emissions in the urban transport and water sectors, and new comprehensive guidelines on supporting cities to identify suitable measuring and monitoring tools for emissions in key urban sectors (see box 14).

[45] See http://www.iadb.org/en/news/news-releases/2016-07-28/santo-andre-in-brazil-to-improve-transport,11526.html.

[46] See https://publications.iadb.org/handle/11319/7743.

Box 14
Examples of technical support for low emissions development

Support for a holistic approach to low-emission urban development and training of city planners

The Global Platform for Sustainable Cities,[c] led by the World Bank, promotes an integrated approach to urban sustainability planning and financing. It currently supports 30 cities in 11 pilot countries in using geospatial data and tools for integrated urban planning and in preparing and implementing action plans, and it provides capacity-building support to improve municipal finances and creditworthiness and identify priorities for urban investments. The World Bank also offers the City Climate Planner Certificate Program,[b] which aims to increase the global talent base of local low-emission city planning specialists through the provision of in-person and online training on greenhouse gas inventories.

Support for the deployment of renewable energy technologies

The International Renewable Energy Agency (IRENA) assists its member countries to accelerate the deployment of renewable energy technologies by identifying feasible and cost-effective approaches and concrete technology options for countries and sectors, assessing policy and investment implications and outlining economic, environmental and social benefits. Among other services, it provides a free online knowledge base, including a platform for patents and standards,[e] as well as hands-on support to countries in the development of renewable energy projects from concept to deployment. IRENA also offers the Project Navigator,[d] which is a free online tool that allows users to develop bankable renewable energy projects through a seven-step approach.

Support for cities to reduce emissions in the urban transport and water sectors

The German development cooperation agency Gesellschaft für Internationale Zusammenarbeit (GIZ) provides support for a wide variety of actions, including actions aimed at developing low-emission urban transportation and emission reductions from wastewater treatment, in developing countries. To promote sustainable low-emission urban transport, it focuses on capacity-building at the individual and organizational levels, for example through the provision of support for the development of low-emission transport strategies or bankable projects. GIZ supports two international urban partnerships, Mobilise Your City,[c] a network of 100 cities in developing countries that promotes sustainable urban mobility planning, and the Transformative Urban Mobility Initiative,[f] which facilitates the mobilization of investments in sustainable urban transport infrastructure and builds capacity of decision makers. In wastewater treatment, an example of support provided by GIZ is the implementation of the Water and Wastewater Companies for Climate Mitigation project,[g] which encourages utilities to reduce their greenhouse gas emissions and energy consumption. Pilot projects are under way in Madaba, Jordan, in San Francisco del Rincón, Mexico, in Cusco, Peru, and in Chiang Mai, Thailand. So far, the projects have led to a 12–50 per cent reduction in the respective utilities' total greenhouse gas emissions.

Compendium on Greenhouse Gas Baselines and Monitoring

To provide support in the assessment of emission reductions from mitigation actions implemented at different scales in the number of sectors, a number of international organizations have contributed to the creation of the *Compendium on Greenhouse Gas Baselines and Monitoring*. The compendium seeks to assist in assessing national and sectoral emissions trajectories and making informed choices when developing and implementing mitigation actions as well as providing tools for measuring progress towards achieving them. To date, five volumes of the compendium have been developed:[h]

- National-level mitigation actions;
- Passenger and freight transport;
- Manufacturing industries and construction;
- Agriculture, forestry and other land use;
- Residential, commercial and public buildings.

The compendium provides an overview of the tools available for establishing baselines and setting emission reduction targets and goals to enable users to estimate the mitigation impact of actions taken to reach these goals and measure progress towards achieving them.

Green City Tool

The European Commission is developing a new online tool[i] to support cities in self-assessing their operations, setting targets and measuring progress over time, identifying funding opportunities, and sharing experience and networks with other cities. The tool will offer cities guidance and suggest policy actions that other European cities, which are in a similar situation, have taken. Data and other information in the tool will support cities in communicating their efforts to citizens, investors and other stakeholders.

Source: Presentation at the technical expert meeting on mitigation in May 2017.

[a] See http://www.worldbank.org/en/topic/urbandevelopment/brief/global-platform-for-sustainable-cities

[b] See http://www.worldbank.org/en/topic/climatechange/brief/city-climate-planner-certificate-program

[c] See http://inspire.irena.org/Pages/default.aspx

[d] See https://navigator.irena.org/index.html

[e] See http://mobilisevourcity.net/initiative

[f] See http://transformative-mobility.org/#what-we-do

[g] See http://wacclim.org

[h] See http://mitigationandtransparencyexchange.org/

[i] See http://ec.europa.eu/environment/urban/tool.htm

V. Possible next steps to accelerate implementation in the pre-2020 period

67. This chapter summarizes the views presented by Parties and non-Party stakeholders on the next steps in the technical examination of opportunities for addressing cross-cutting issues in urban environments in the pre-2020 period and the views related to future political and technical work to enhance mitigation ambition.

A. Overview of the next steps for accelerating actions that address cross-cutting issues in urban environments

68. Achieving the mitigation ambition appropriate for avoiding dangerous climate change requires the pooling of resources from diverse actors through multi-stakeholder partnerships to mobilize and share knowledge, expertise, technology and finance, particularly within developing countries. TEMs continue to provide a space for Parties and non-Party stakeholders to interact with each other and identify new opportunities for collaboration and building partnerships and to showcase the results achieved and ways to scale up existing initiatives that are well positioned to accelerate the global response to climate change in the pre-2020 period and, in this way, to prepare a foundation for the implementation of the Paris Agreement.

69. Building partnerships with non-Party stakeholders and intensifying engagement with the private sector to accelerate market uptake of low-emission technologies and practices, such as through public–private partnerships on renewable energy technologies, is an important opportunity that needs to be further explored.

70. The coordination of support for low-emission policies, technologies and practices in urban environments is key to enabling more targeted and impactful assistance to developing countries that facilitates meeting national sustainable development objectives and mitigation targets.

71. Gender equality and sustainable urbanization are crucial not only for enhancing the liveability of cities, but also for the realization of global commitments and targets, including the SDGs. For urbanization to be sustainable, governments, policymakers and the development community need to understand the gender impacts of rapid urbanization. When urban design and services, including water, sanitation, transport and markets, address gender discrimination and promote equal opportunities, greater social and economic benefits can be achieved. Women, as primary family caretakers, are important agents of

change who could encourage the use of public transport, sustainable consumption patterns and climate-friendly lifestyle changes in their families. Girls' and women's education is therefore among the key actions to promote and enhance mitigation action in cities.

B. Options for advancing the technical examination process

72. COP 21 decided to appoint two high-level champions to act on behalf of the President of the COP to facilitate, through strengthened high-level engagement in the period 2016–2020, the successful execution of existing efforts and the scaling-up and introduction of new or strengthened voluntary efforts, initiatives and coalitions.[47] The high-level champions developed the Road Map for Global Climate Action,[48] presented it at a special event during the forty-fourth sessions of the subsidiary bodies and launched a call for submissions on the road map in May 2016,[49] where the champions invited views from Parties[50] and non-Party stakeholders.[51]

73. In the same decision, the COP decided to conduct in 2017 an assessment of the technical examination process so as to improve its effectiveness.[52] Although there was no call for submissions to invite views on the conduct of the assessment of the effectiveness of the process, the submissions on the road map received from Parties and non-Party stakeholders in response to the call of the high-level champions (see para. 72 above) expressed views on aspects and actors in the technical examination process, including on the role of TEMs.

74. In response to the call for submissions on the road map, Parties[53] underlined that the TEMs provide a valuable platform for the sharing of good practices and the promotion of cooperation, and supported the view of the high-level champions that the TEMs should evolve in the light of the road map. In this regard, Parties made the following proposals:

(a) Coherence between the road map and the TEMs should be ensured;

(b) Cooperation between the high-level champions and the secretariat on the selection of topics for sessions of the TEMs should be fostered;

(c) The focus of sessions of the TEMs should be narrowed to allow participants to engage in more in-depth technical and practical discussions;

(d) Sessions of the TEMs should focus on scaling up existing initiatives, taking forward opportunities for greater multi-stakeholder cooperation, and overcoming barriers to implementation;

(e) Sessions of the TEMs should be organized to allow for smaller breakout groups, to facilitate interactivity and learning;

(f) Speakers should be invited and information on the focus and objectives of each session of the TEMs should be made available well in advance;

(g) Participation of developing country experts should be supported, including through webinars and other forms of virtual participation;

(h) Sessions of the TEMs should be organized at the regional level in coordination with the secretariat, constituted bodies under the Convention such as the CTCN, and a host country.

75. Parties also recognized the importance of the active engagement of non-Party stakeholders in driving concrete and innovative climate action, including through their

[47] Decision 1/CP.21, paragraph 121.
[48] http://newsroom.unfccc.int/media/658505/high-level-champions-climate-action-roadmap.pdf.
[49] http://newsroom.unfccc.int/media/658506/high-level-champions-invitation-submissions.pdf.
[50] http://www4.unfccc.int/submissions/SitePages/sessions.aspx?search=Roadmap.
[51] http://unfccc.int/documentation/items/9636.php.
[52] Decision 1/CP.21, paragraph 113.
[53] http://www4.unfccc.int/submissions/SitePages/sessions.aspx?search=Roadmap.

participation in the TEMs, and invited other Parties to engage non-Party stakeholders also at the national level.

76. The views expressed in submissions of non-Party stakeholders echoed the views of Parties. Non-Party stakeholders considered the TEMs as a valuable platform for dialogue between governments and themselves, and indicated a desire to see the TEMs evolve to become more solutions-oriented and thereby result in tangible changes to domestic policy, informed by real-world experience in pioneering climate action and catalysing additional ambition from the private sector. To achieve this, non-Party stakeholders suggested the following:

(a) The participation of non-Party stakeholders in the TEMs should be increased, including the participation of subnational authorities, the private sector, including industry experts beyond international organizations to include technology providers and professional associations;

(b) More time should be provided for questions and answers and dialogue between non-Party stakeholders and policymakers, and a round-table format should be used to encourage interaction and dialogue;

(c) Regional TEMs, covering topics of regional interest, should be organized on the margins of existing sectoral events that take place in different regions.

C. Options for work at the political level to enhance mitigation ambition

77. The Road Map for Global Climate Action referred to in paragraph 72 above described the tasks and activities of the high-level champions in the run-up to COP 22. The high-level champions proposed to ensure a durable connection between the UNFCCC process and the many voluntary and collaborative actions by:

(a) Engaging with interested Parties and non-Party stakeholders, including furthering the voluntary initiatives of the Lima–Paris Action Agenda[54] by: building on existing initiatives and supporting new and more geographically diverse initiatives; connecting initiatives and coalitions with national action plans such as nationally determined contributions; and improving transparency, tracking results and demonstrating credibility;

(b) Providing guidance to the secretariat on the organization of TEMs and working with the Executive Secretary and the current and incoming Presidents of the COP to coordinate annual high-level events.

D. Possible role of the Marrakech Partnership for Global Climate Action

78. In November 2016, the high-level champions launched the Marrakech Partnership for Global Climate Action as a way for future high-level champions to catalyse and support climate action by Parties and non-Party stakeholders in the period 2017–2020. The Marrakech Partnership aims to, inter alia, enable a greater connection and coherence between individual TEMs and ongoing regional activities to support and accelerate implementation.[55]

79. In May 2017, the high-level champions published a document that outlines their approach to realizing the objectives of the Marrakech Partnership up to 2020. To facilitate enhanced high-level engagement at COP 23, a series of high-level round tables will be organized, focusing, inter alia, on the nexus between climate action and SDG 11 on making cities and human settlements inclusive, safe, resilient and sustainable.[56] These round tables will build on discussions held at the TEMs during the forty-sixth sessions of the subsidiary

[54] http://newsroom.unfccc.int/lpaa/about/.

[55] http://unfccc.int/files/paris_agreement/application/pdf/marrakech_partnership_for_global_climate_action.pdf.

[56] http://unfccc.int/files/paris_agreement/application/pdf/gca_approach.pdf (see para. 18).

bodies,[57] with a focus on urban planning for resilience in coastal cities, energy efficiency in buildings, decarbonization of urban transport, water and sanitation in the context of climate-induced water scarcity, and flooding and salinization.[58]

[57] http://unfccc.int/files/paris_agreement/application/pdf/gca_approach.pdf (see para. 19).
[58] http://unfccc.int/files/paris_agreement/application/pdf/gca_approach.pdf (see para. 20).

References

CCFLA (Cities Climate Finance Leadership Alliance). 2015. *The State of City Climate Finance 2015*. Available at http://www.citiesclimatefinance.org/wp-content/uploads/2015/12/CCFLA-State-of-City-Climate-Finance-2015.pdf.

Covenant of Mayors. 2016. *Greenhouse Gas Emissions Achievement and Projections. European Commission Joint Research Centre Science for Policy Report*. Available at http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103316/jrc103316_com%20achievements%20and%20projections_online.pdf.

Creutzig F, Baiocchi G, Bierkandt R, Pichler P-P and Seto KC. 2015. Global typology of urban energy use and potentials for an urbanization mitigation wedge. *Proceedings of the National Academy of Sciences of the United States of America*. 112(20): pp.6283–6288. Available at http://www.pnas.org/content/112/20/6283.full.

Creutzig F, Jochem P, Edelenbosch OY, Mattauch L, van Vuuren DP, McCollum D and Minx J. 2015. Transport: a roadblock to climate change mitigation? *Science*. 350(6263): pp.911 and 912.

Creutzig F, Agoston P, Minx JC, Canadell JG, Andrew RM, Quéré CL, Peters GP, Sharifi A, Yamagata Y and Dhakal S. 2016. Urban infrastructure choices structure climate solutions. *Nature Climate Change*. 6(12): pp.1054–1056.

Data-Driven Yale (Yale Data-Driven Environmental Solutions Group). 2016. *Taking Stock of Global Climate Action*. Available at http://datadriven.yale.edu/wp-content/uploads/2016/12/Data_Driven_Yale_Taking-Stock-of-Global-Climate-Action_Nov_2016_final.pdf.

EPRI (Electric Power Research Institute). 2015. *Environmental Assessment of a Full Electric Transportation Portfolio*. Available at https://www.epri.com/#/pages/product/3002006881/.

GCEC (Global Commission on the Economy and Climate). 2015. *Accelerating Low-carbon Development in the World's Cities*. New Climate Economy Working Paper. Available at http://newclimateeconomy.report/2015/wp-content/uploads/sites/3/2015/09/NCE2015_workingpaper_cities_final_web.pdf

GCEC. 2016. *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development. The 2016 New Climate Economy Report*. Available at http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2014/08/NCE_2016Report.pdf.

IEA (International Energy Agency). 2016a. *Energy Technology Perspectives 2016: Towards Sustainable Urban Energy Systems*. Available at https://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives2016_ExecutiveSummary_EnglishVersion.pdf.

IEA. 2016b. *Energy Efficiency Market Report 2016*. Available at https://www.iea.org/publications/freepublications/publication/mediumtermenergyefficiency2016.pdf.

IMF (International Monetary Fund). 2015. *How Large Are Global Energy Subsidies?* IMF Working Paper. Available at https://www.imf.org/en/Publications/WP/Issues/2016/12/31/How-Large-Are-Global-Energy-Subsidies-42940.

IPCC. 2007. *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. B Metz et al. (eds.). Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/report/ar4/wg3/.

IPCC. 2014a. Buildings. *In*: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* O Edenhofer et al. (eds.). Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter9.pdf.

IPCC. 2014b. Human settlements, infrastructure, and spatial planning. *In*: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* O Edenhofer et al. (eds.). Cambridge and New York: Cambridge University Press. Available at https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter12.pdf.

IRENA (International Renewable Energy Agency). 2016. *Roadmap for a Renewable Energy Future.* Available at http://www.irena.org/remapw

LEDS (Low Emission Development Strategies Global Partnership, Working Group on Subnational integration). 2014. *What National Governments Can Do to Accelerate Subnational Action on Climate: Synthesis of Current Research And Good Practice.* Available at http://www.ecofys.com/files/files/ledsgp-sni-paper-bonn-2014.pdf.

McKinsey Global Institute. 2016. *Bridging Global Infrastructure Gaps.* Available at http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/bridging-global-infrastructure-gaps.

OECD (Organisation for Economic Co-operation and Development). 2014. *Cities and Climate Change: National Governments Enabling Local Action.* Available at http://www.oecd.org/env/cc/Cities-and-climate-change-2014-Policy-Perspectives-Final-web.pdf.

Sustainia and C40 (C40 Cities Climate Leadership Group). 2016. *Cities 100.* Available at http://issuu.com/sustainia/docs/cities100/85?e=4517615/31305566.

UNEP (United Nations Environment Programme) and ISWA (International Solid Waste Association). 2015. *Global Waste Management Outlook.* Available at http://www.unep.org/ourplanet/september-2015/unep-publications/global-waste-management-outlook

UNEP. 2016. *Towards Zero-Emission Efficient and Resilient Buildings. Global Status Report 2016.* Available at https://wedocs.unep.org/rest/bitstreams/45611/retrieve.

UN-Habitat (United Nations Human Settlements Programme). 2013. *Addressing Urban Issues in National Climate Change Policies: Cities and Climate Change Initiative. Policy Note 3.* Available at https://unhabitat.org/addressing-urban-issues-in-national-climate-change-policies-cities-and-climate-change-initiative-policy-note-3/.

UN-Habitat. 2017. *Urbanization and Development: Emerging Futures. World Cities Report 2016.* Available at http://wcr.unhabitat.org.

UN-Habitat and UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific). 2015. *The State of Asian and Pacific Cities 2015: Urban Transformations, Shifting from Quantity to Quality.* Available at http://www.unescap.org/sites/default/files/The%20State%20of%20Asian%20and%20Pacific%20Cities%202015.pdf.

UN DESA (United Nations Department of Economic and Social Affairs). 2015. *World Urbanization Prospects. The 2014 Revision.* Available at https://esa.un.org/unpd/wup/publications/files/wup2014-report.pdf.